Pyrotechnic Devices, Shock Levels And Their Applications

by
Kurng Y. Chang
Jet Propulsion Laboratory
California Institute of Technology

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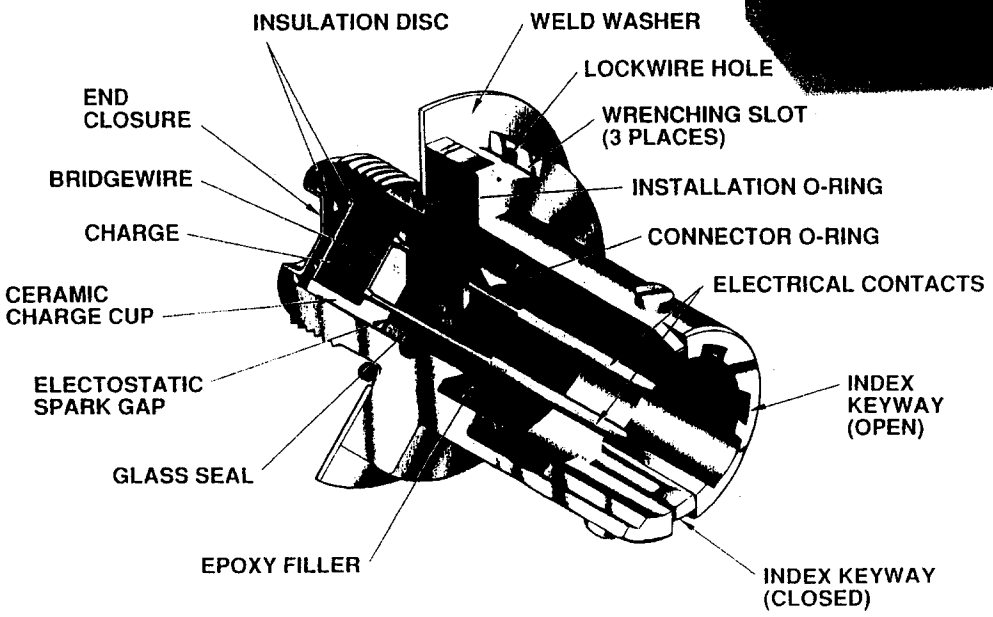
Pyrotechnic Devices, Shock Levels And Their Applications
(OUTLINE)

- **Device Categories and Applications**
- **Devices Shock Characteristics and Levels**
- **Comparison of Device Shock Levels**
- **Summary Remarks**
- **References**

Pyroshock Devices in Aerospace Usage

- Ordnance Devices
  - NASA Standard Initiator (NSI)
  - Explosive Cord
- Low Explosive Actuation
  - Bellows Actuators
  - Pyro Valves
  - Pin-Pullers
  - Ball Latch
  - Cable or Bolt Cutters
  - Separation Nuts
  - V-Bands
- High Explosive Actuation
  - "Super*Zip" (Linear Separation Assembly)
  - Flexible Linear Shape Charge (FLSC)

NASA Standard Initiator



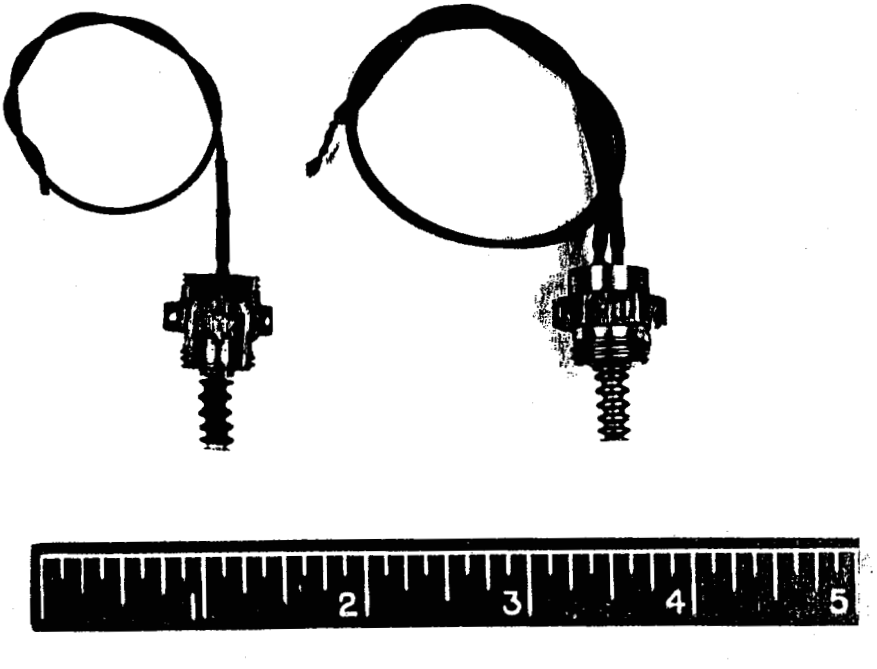
1. Bellows Actuators

Designed to yield a motion and force upon initiation, and is used for latch release of instrument covers. Shock output is quite low and will not have any significant affect on instruments.

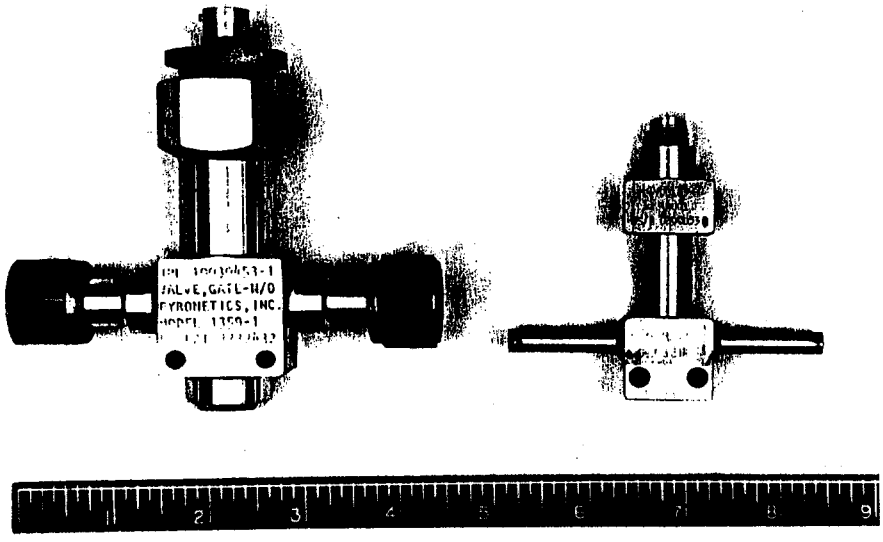
2. Pyro Valves

Used as assembly internal devices. Primary application is release of high-pressure gas from storage bottles to pressurize pneumatic systems after spacecraft launch. Provides safety, lower system pressure design margins and lower weight. Shock generated will not affect other assemblies or equipment.

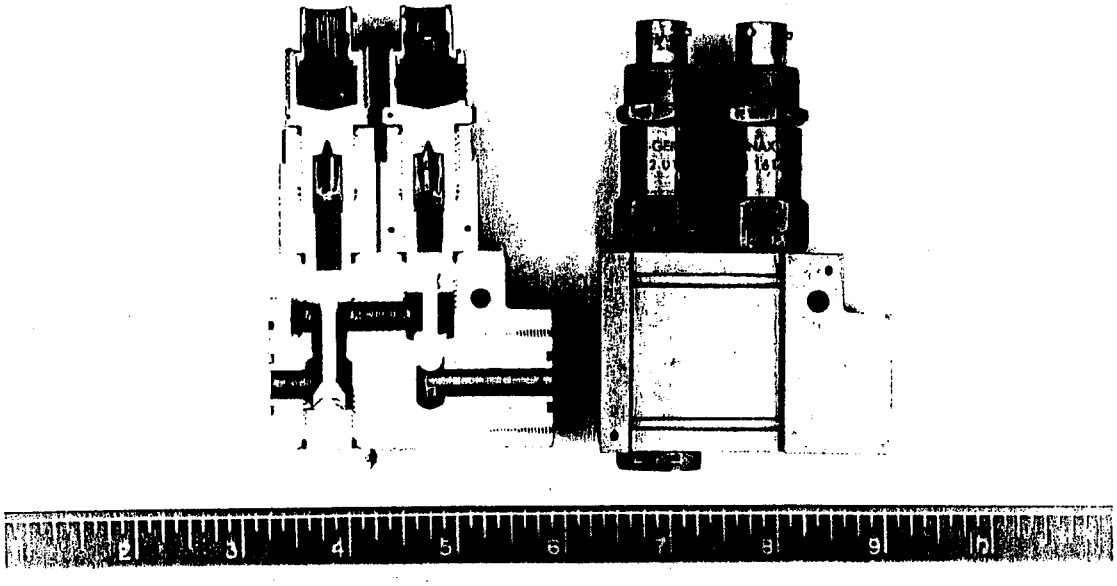
Bellows Actuators



Pyro Valves



Double Barrel Pyro Valves



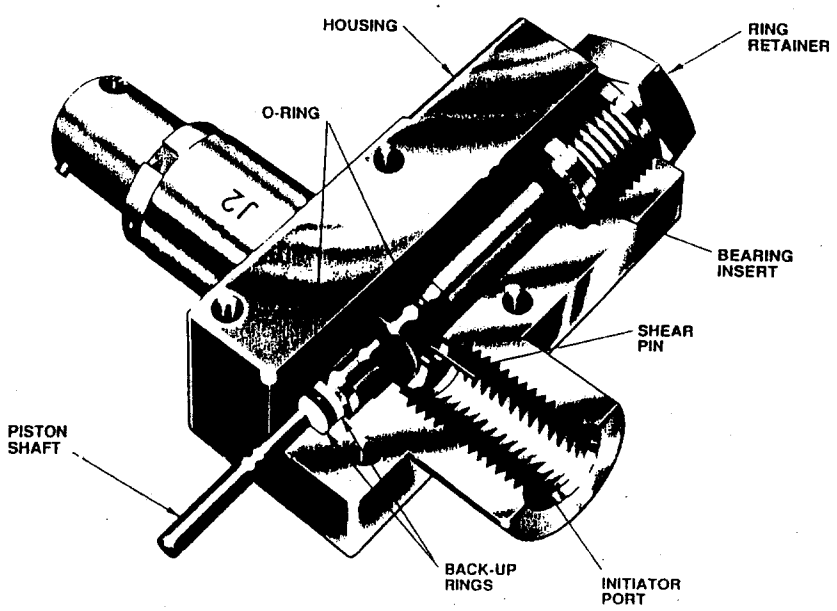
3. Pin-Pullers

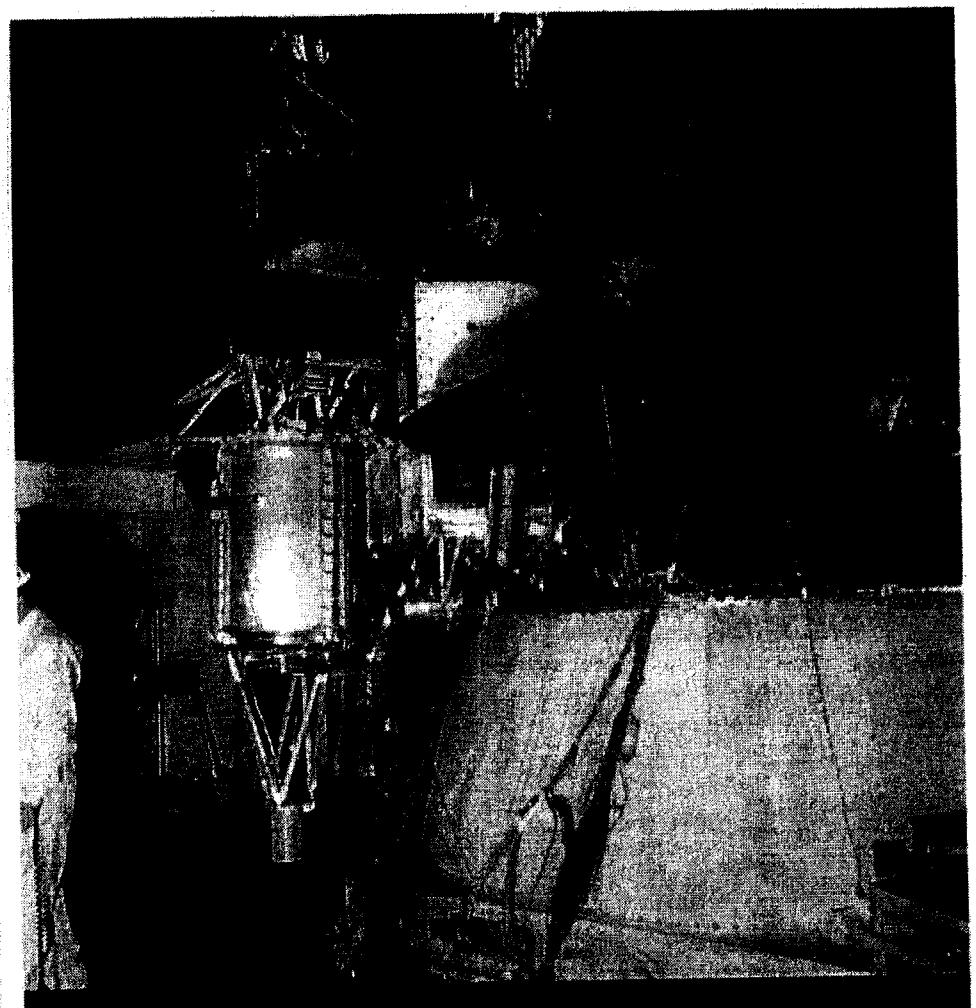
Designed to carry loads in shear. Used primarily for the release of stowable subsystems such as flight instruments, solar arrays and antennas, where high load transmission is not required.

Shock environment measured in near field, on a shock response spectrum* (SRS) basis, may be as high as that from high explosive devices. This generally results from these devices being mounted on lighter weight structure, and close to sensitive equipment. Shock in these devices is produced by a high speed impacting of the pinpuller on the body of the device and along the pin travelling paths. Shock from these devices is usually a contributor to equipment design criteria.

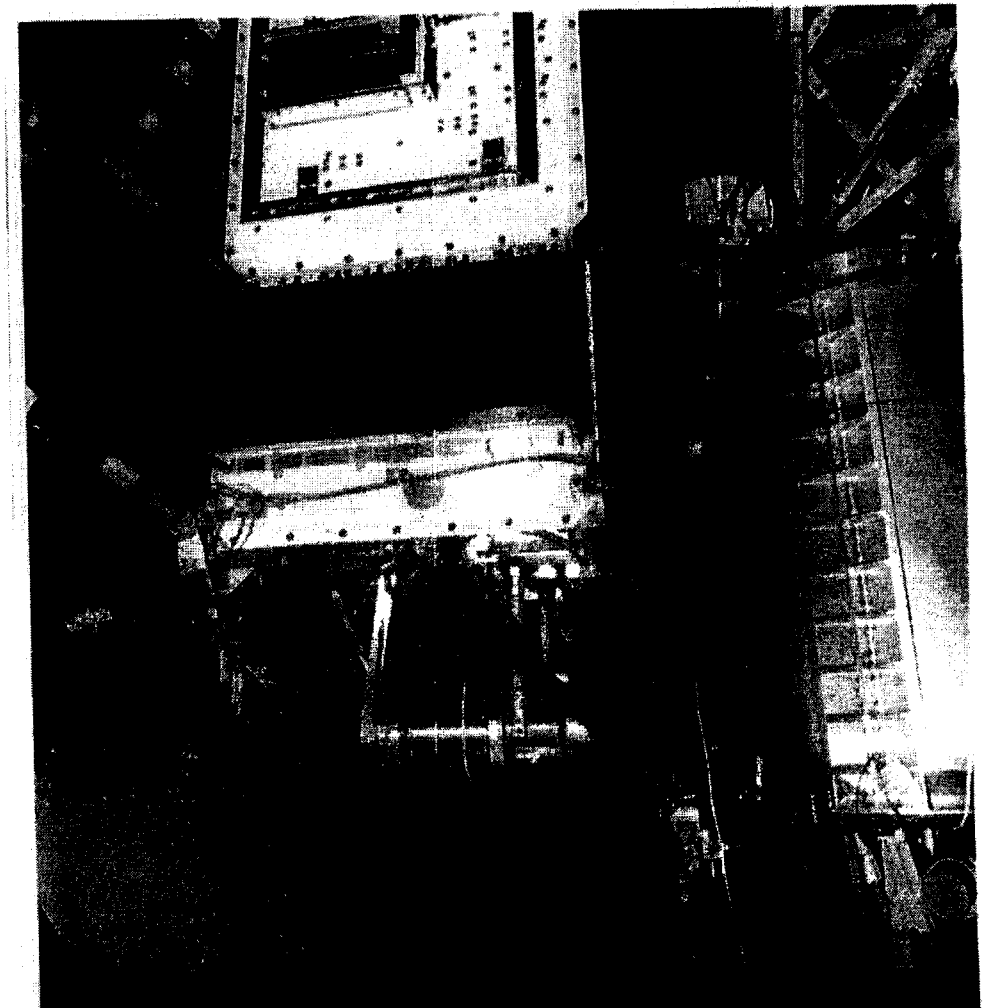
*SRS is currently being used by aerospace industry to define shock pulse severity as well as equipment damage potential.

JPL PIN PULLER ASSEMBLY
P/N 10028045

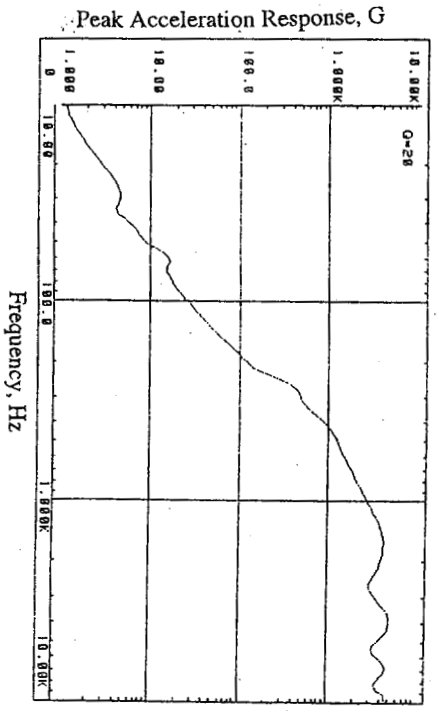


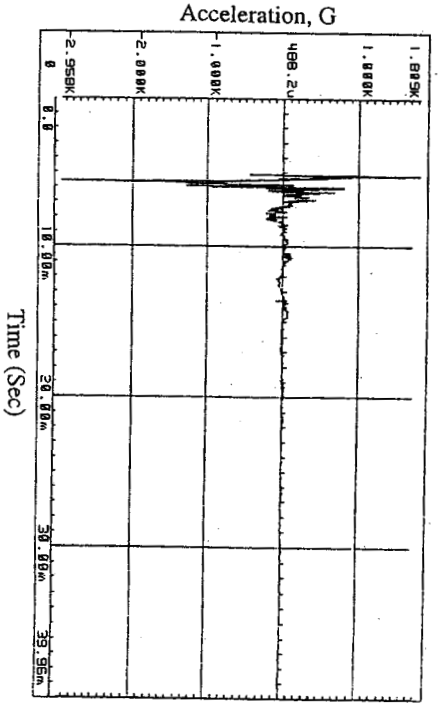


Galileo Science Boom, Magnetometer Canister
and RRH Antenna



Galileo Despun Electronics, Ball Latch
and Pinpullers





Typical Shock Measurement near GLL Antenna Pinpuller

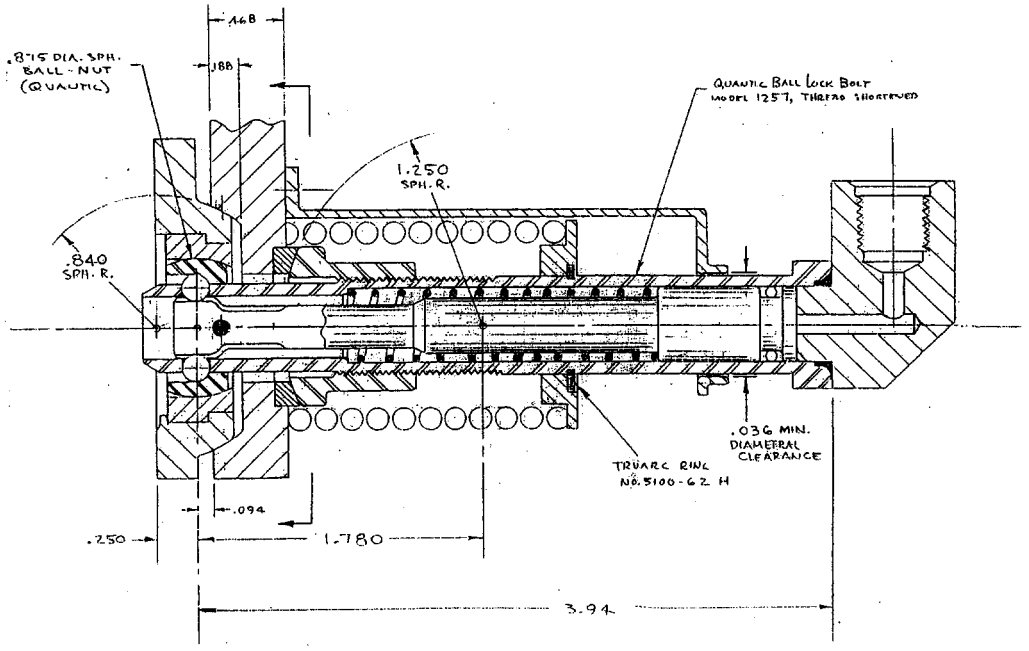
4. Ball Latch

Designed to carry shear and limited tension loads, and are used for the release of launch restrained platform and subsystems. Shock generated from these devices is relatively high and can reach above 10K g in peak SRS level.

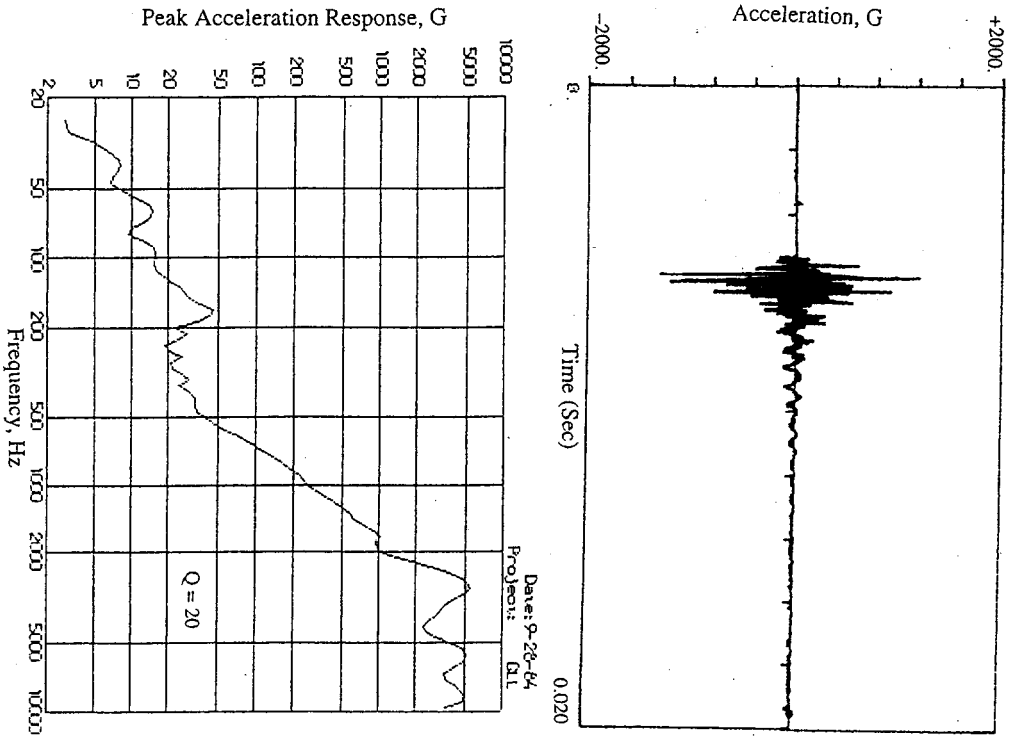
5. Cable or Bolt Cutters

Designed to carry tension loads, and are used for the release of deployable equipment. The shock is generated by the high speed impacting of the cutter blade with the cables or bolts. Shock intensity produced is dependent on the stiffness and size of the umbilical cables or bolts.

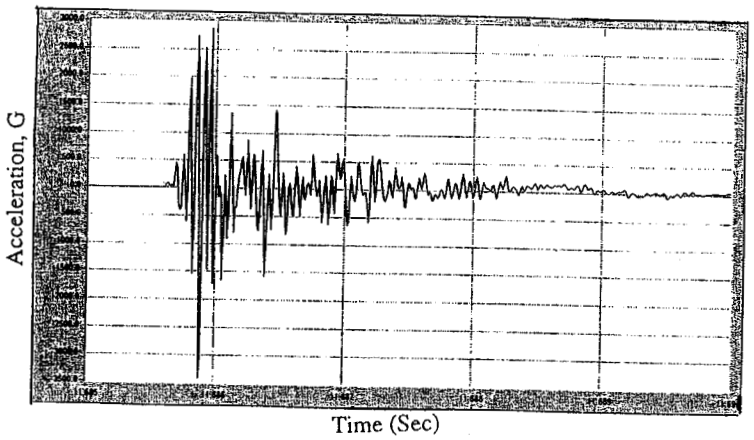
JPL Ball Latch Assembly

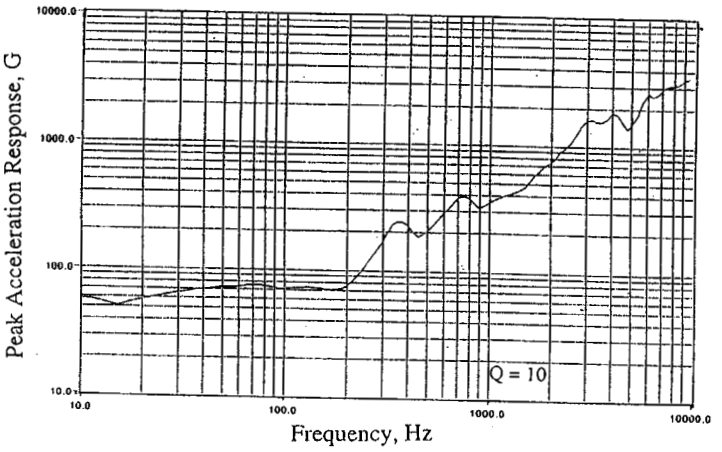


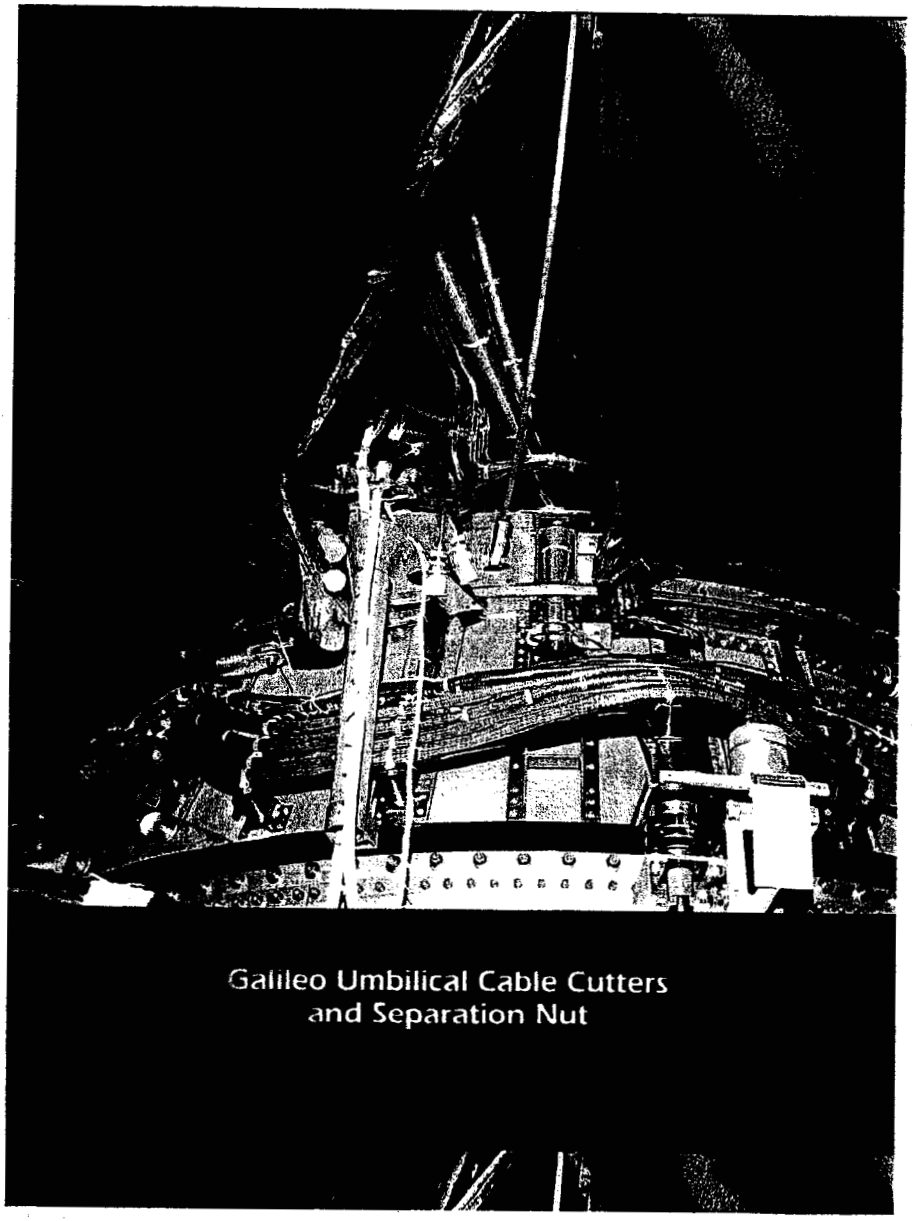
Typical Shock Measurement near GLL Ball Latch Separation



Typical Shock Measurement near a 3/16" Steel Cable Cutter





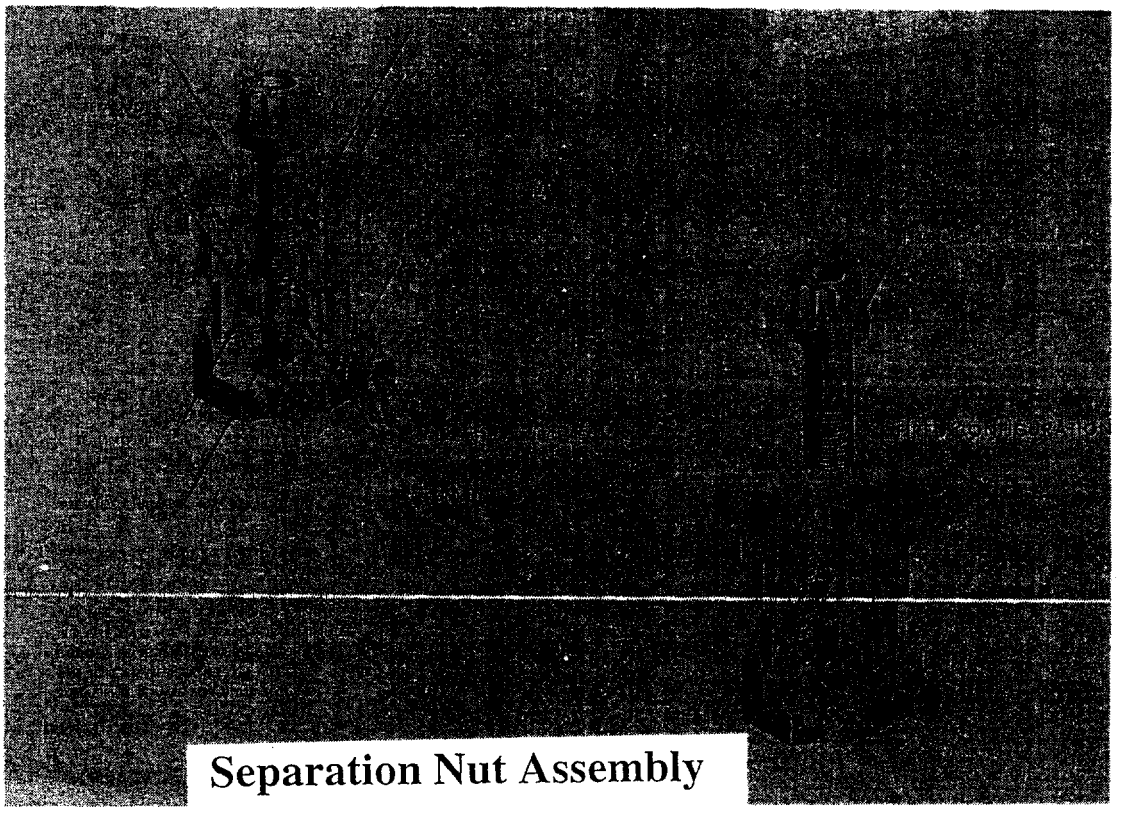


Galileo Umbilical Cable Cutters
and Separation Nut

6. Separation Nuts

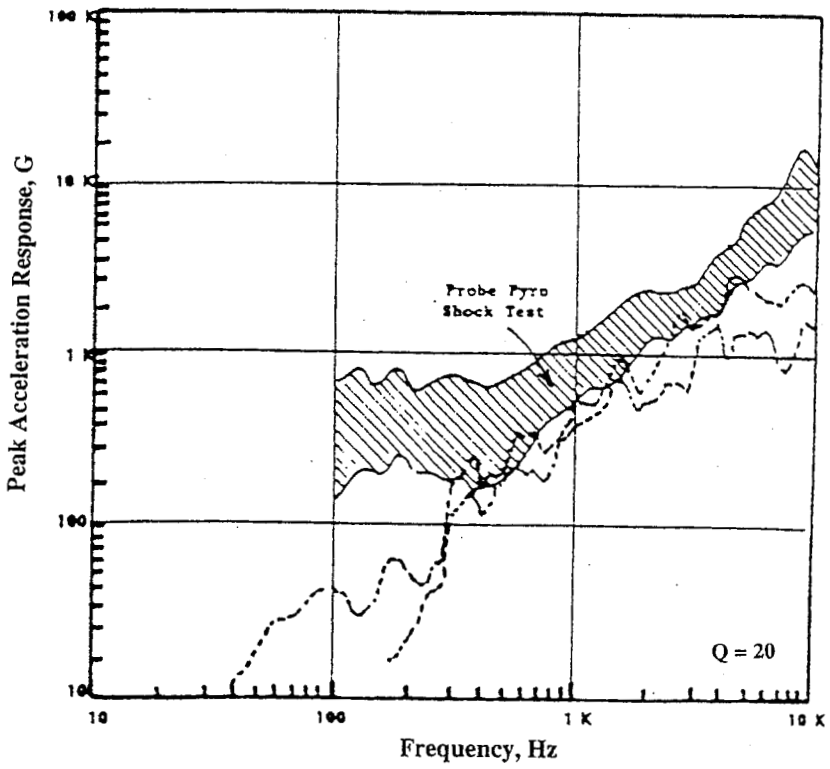
Designed to carry tension loads of bolted joints and planes. Separation nuts have many applications in aerospace systems due to their high load carrying capability and high reliability. It can also be used to separate booster staging and spacecraft from their boosters. They may be used individually to release a bolt, as shown on the following pictures, or used in pairs with a double-ended stud.

Shock environment results from the ordnance squib detonation and impact of the nut mechanism on the body. Comparison of the separation nut shock data indicates that size is not a major factor in determining shock magnitude. The adding of boosters with multi-squib did not significantly change the shock levels. Sudden release of preloaded bolt has not been shown as a significant shock contributor either. The main contributor is the actuation of the internal mechanism.



Separation Nut Assembly

Shock Environment for 5/8" Separation Nuts

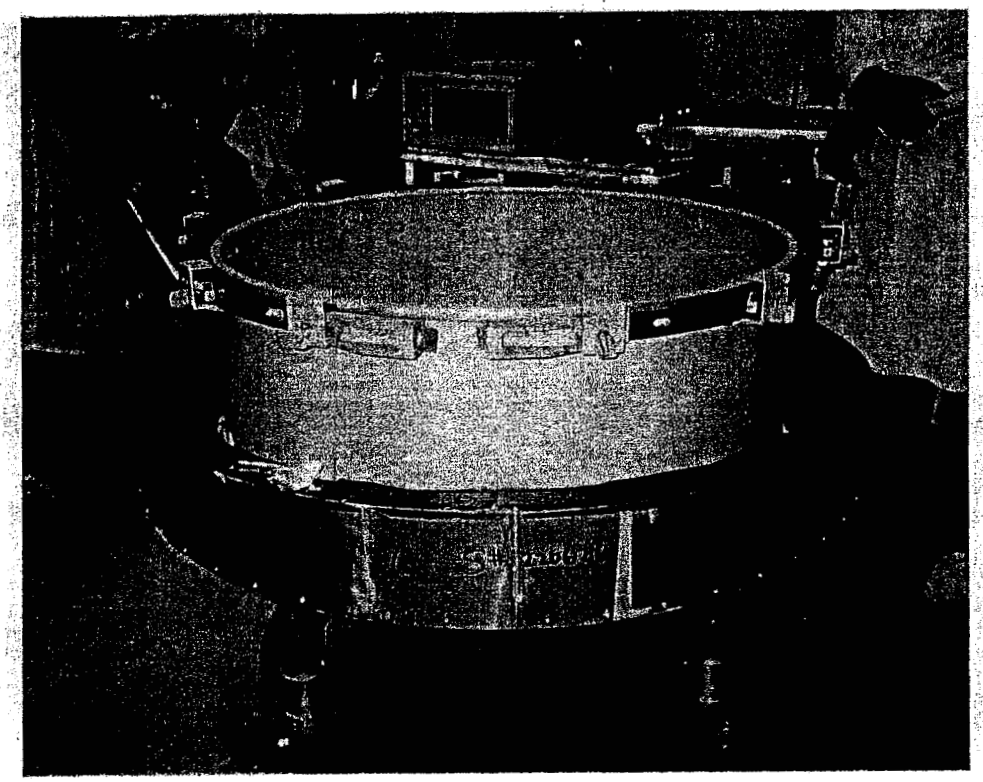


7. V-Bands

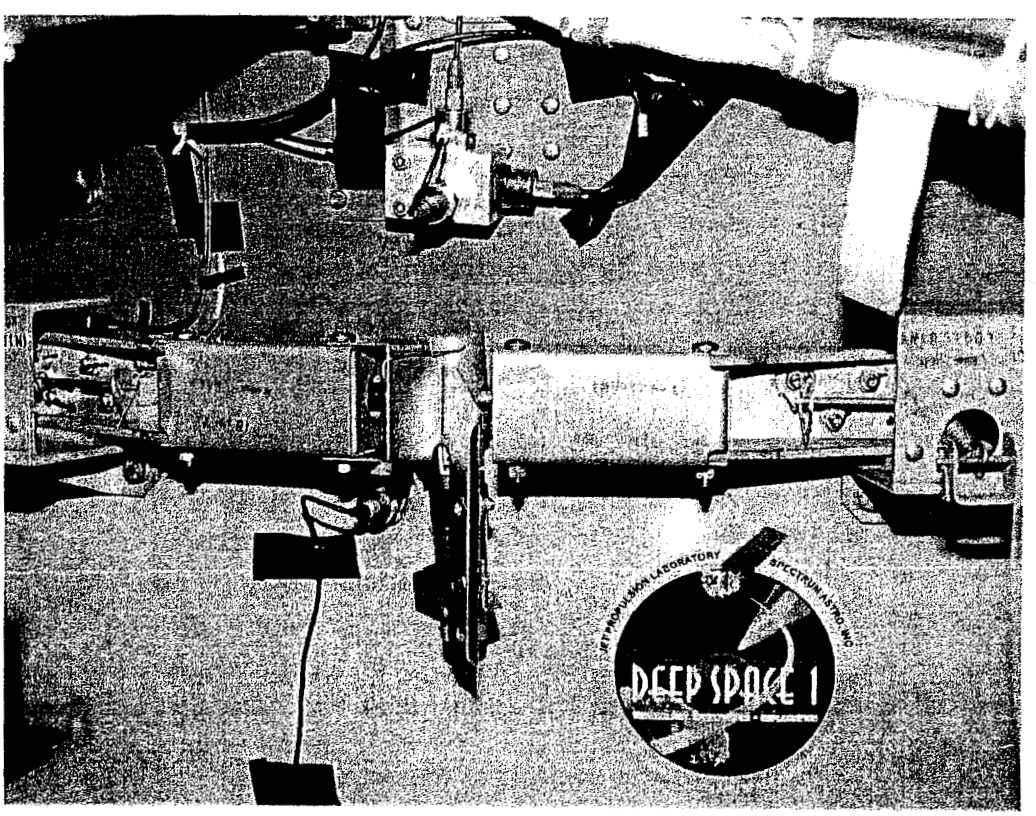
V-band systems have been used to separate missile stages and spacecraft from their boosters, but have a low load carrying capability. V-band is made of eight band segments held by a tensioned strap. Actuation is initiated by firing one or two bolt cutters to rapidly release the tension bands.

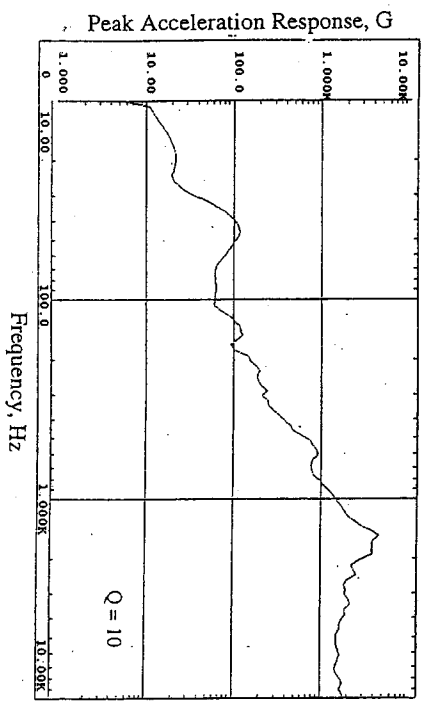
Different from previous predictions, release of the tensioned band and the structural strain energy is not a contributor to the high frequency shock. Shock is generated by the high-speed impact between the upper and lower rings after separation. Shock levels will be attenuated much quicker with distance since this source is a point contact shock rather than a linear distributed source as assumed.

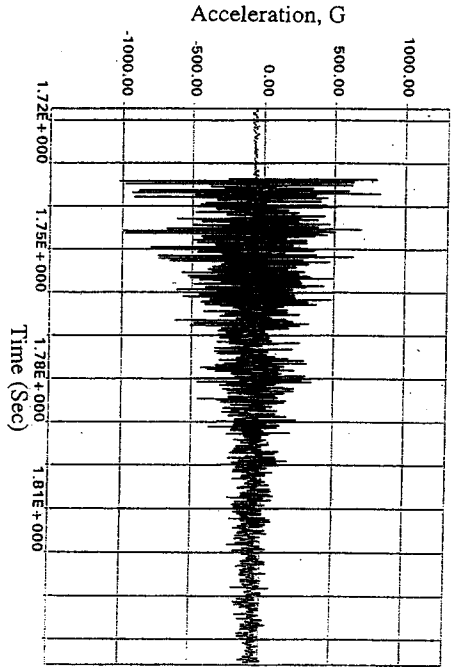
V- Band Assembly



V- Band on Deep Space 1 Spacecraft







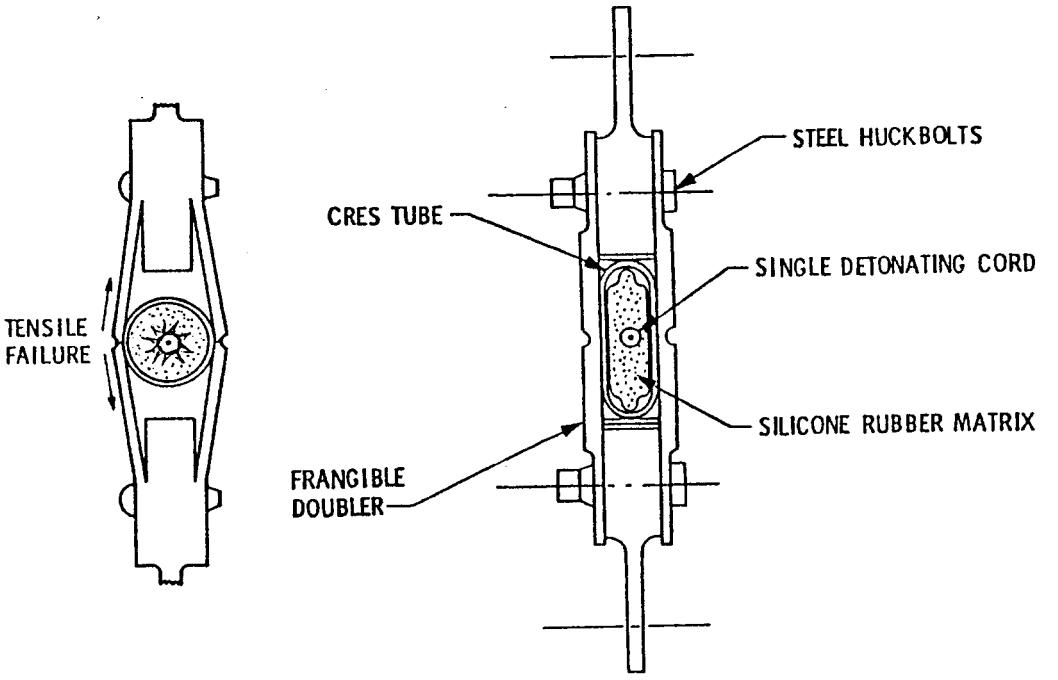
Typical Shock Measurement near DS1 V-Band Separation

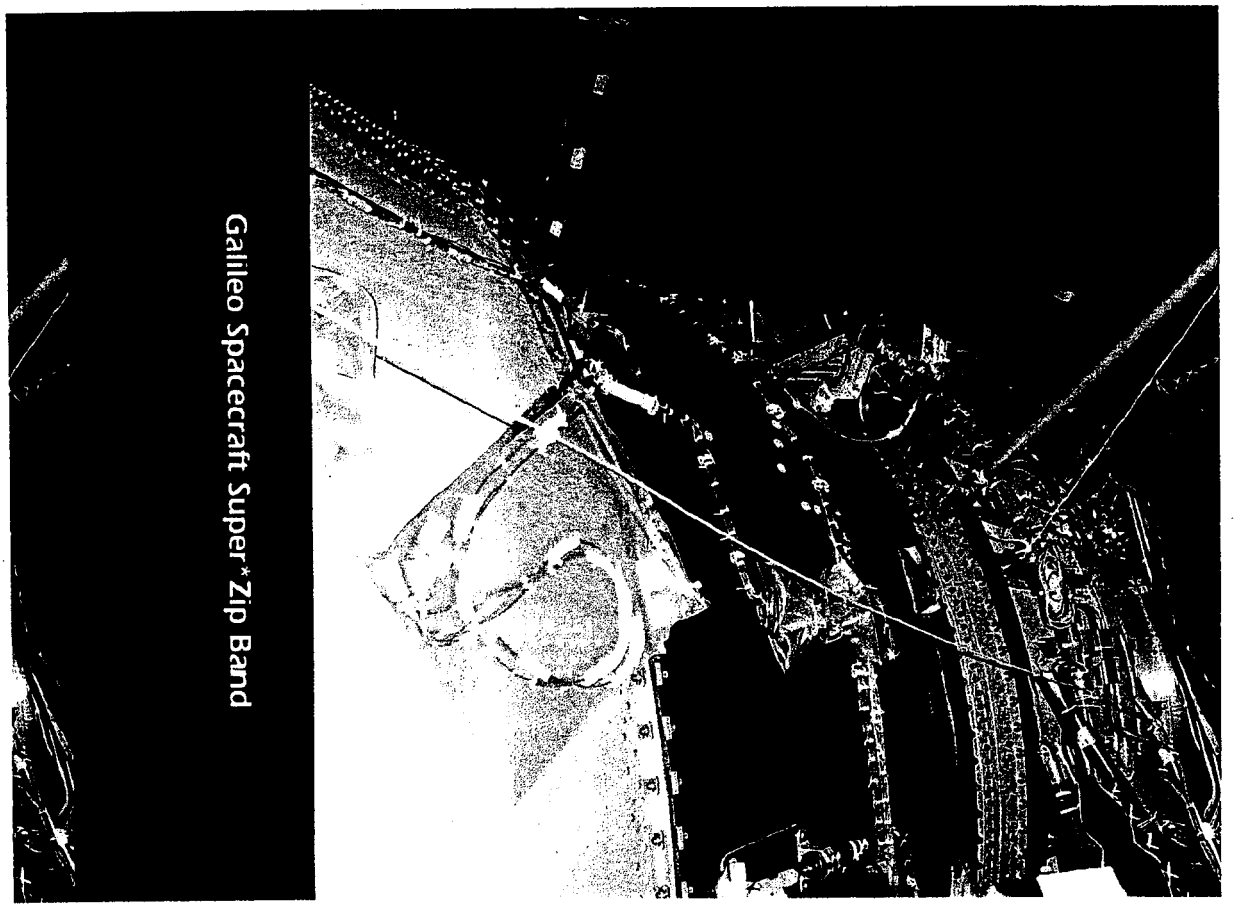
8. Super*Zip

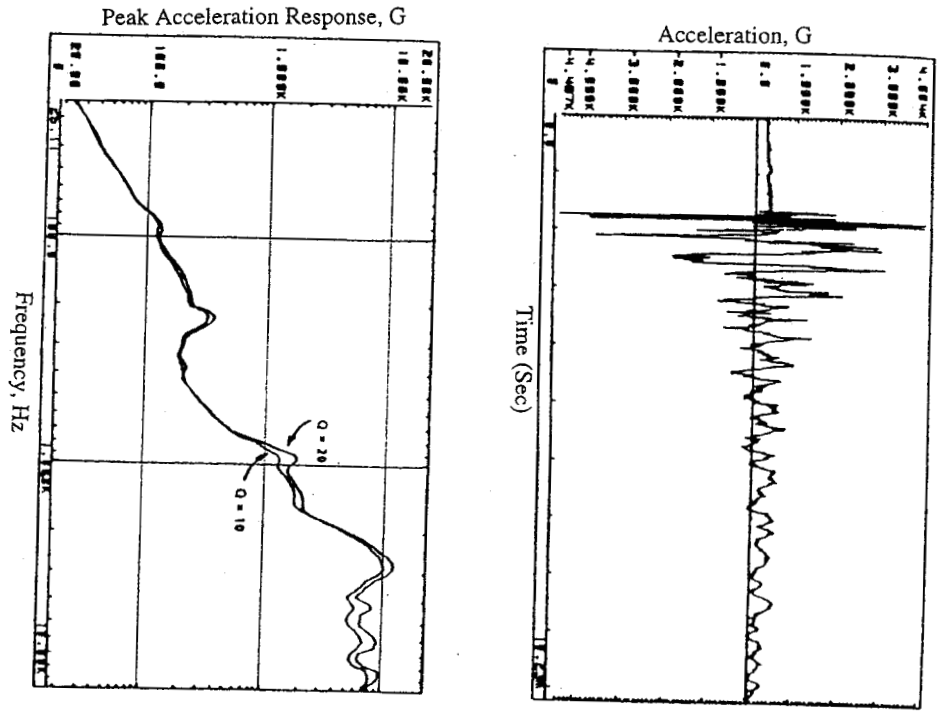
Super*Zip, a product of LMSC, is a high load carrying separation system which activates without contamination. This structure-cutting device is commercially used to separate missile stages, payload fairing and spacecraft from their boosters. Super*Zip is a full circumferential ring which joins two shroud structures. Its cross-section, as illustrated next, is a flattened tube filled with silicone rubber extrusion with a single strand explosive cord from 9 to 13 gr./ft. Outside the tube, two frangible aluminum doublers with a v-notch in the middle are held together by steel huckbolts. Two detonator blocks are used to actuate the explosive charge.

Shock output from this structure fracturing is quite significant and its shock levels can reach above 10K g in peak SRS. Shock responses in all three directions are quite pronounced at a distance away. The effects on shock levels of increasing cord sizes are insignificant and can be neglected. Distance attenuation of the shock level in the shell-type structures is extremely slow and can be disregarded over short distances.

"Super*Zip" Cross-Section







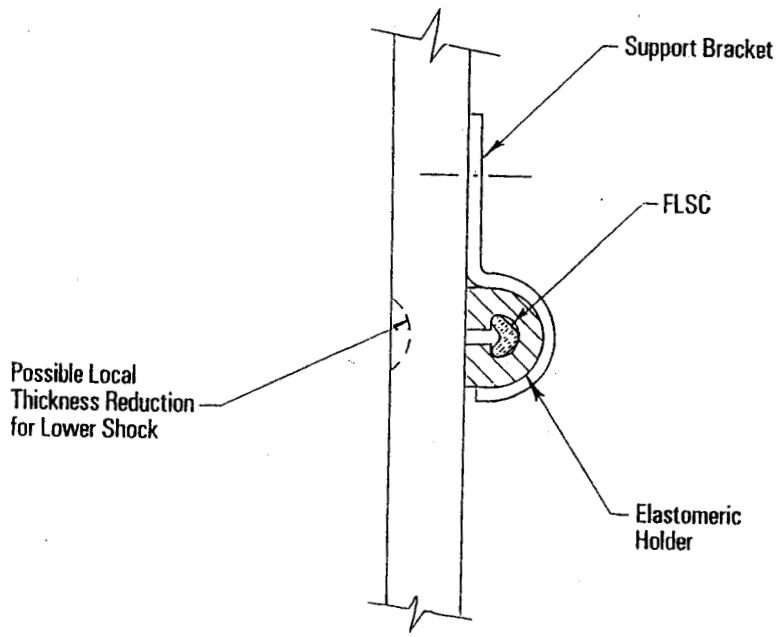
Typical Shock Measurement near a Super*Zip Separation

9. Flexible Linear Shape Charge (FLSC)

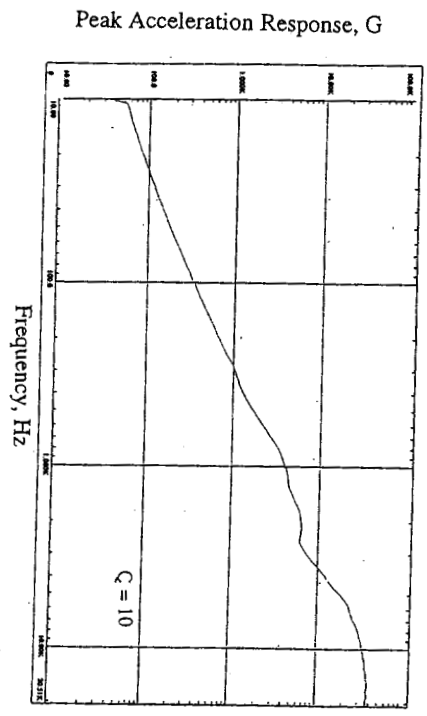
FLSC is one of the greatest shock producers in aerospace separation systems. Used primarily in the high performance missile staging separation. The FLSC is a metal tube, filled with explosive then rolled into a V-shape. Large charges ranging from 10 to 65 gr./ft. of explosive may be employed. This v-shape results in a directed explosion, which cuts the thick metal structure. The FLSC is supported in an elastomeric holder and a backup continuous bracket. Contamination and debris are major problems with this type of separation systems.

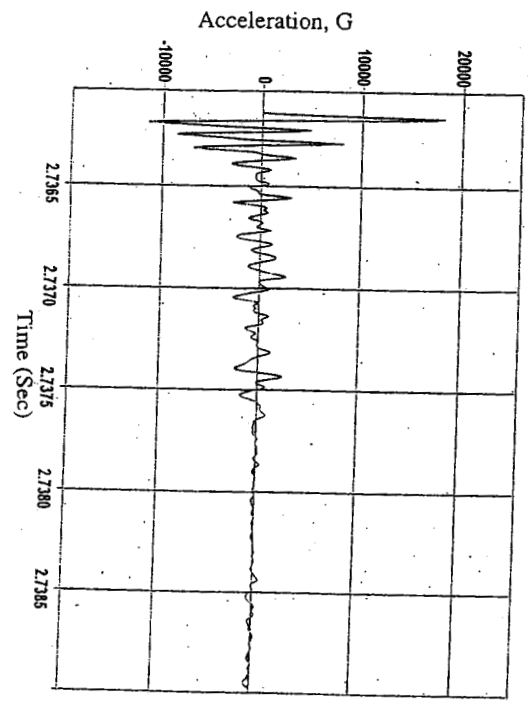
FLSC shock levels are a function of the metal thickness being cut. FLSC can produce shocks whose peak SRS level range from a few thousand g's to 100K g's. Based on assumption of an energy relationship, shock spectra vary with the square root of the thickness being cut.

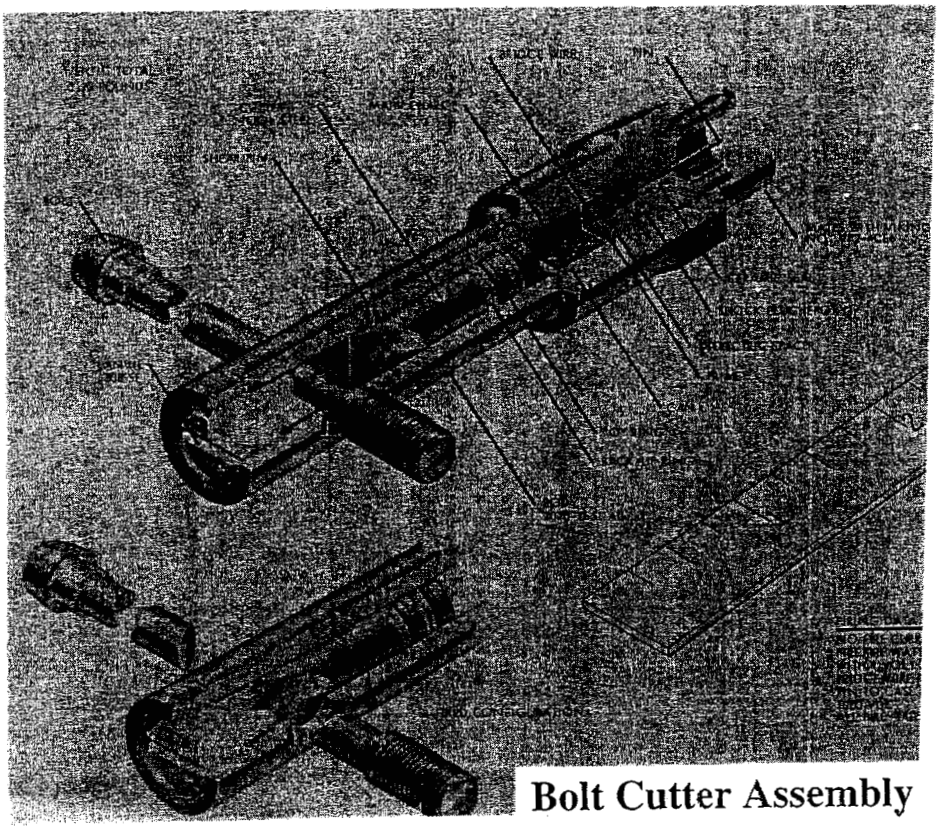
Flexible Linear Shape Charge Cross-Section



Typical Shock Measurement near a FLSC Separation

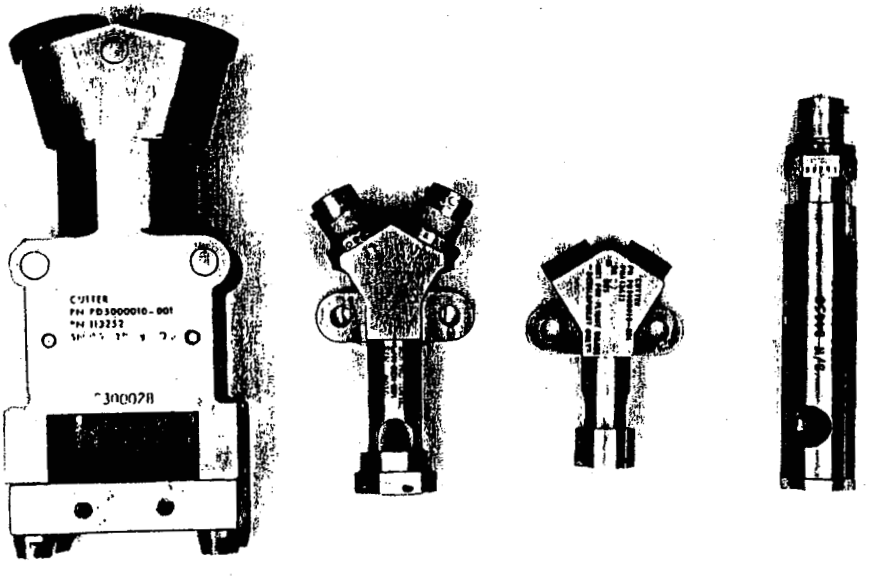




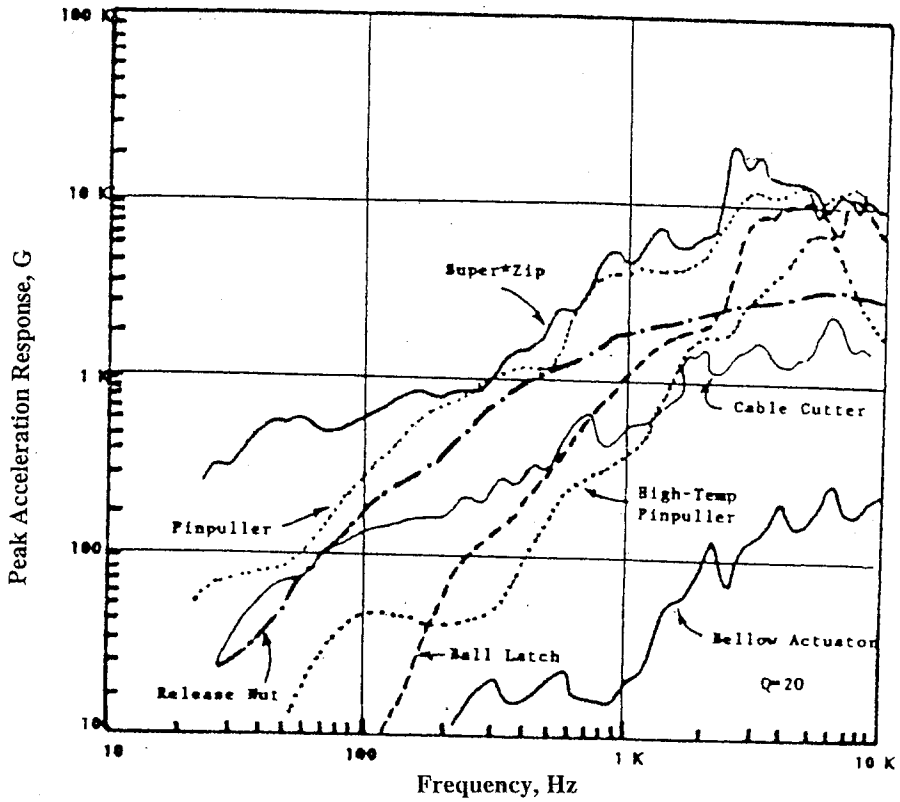


Bolt Cutter Assembly

JPL Cable Cutters



Overall Comparison of Pyrotechnic Device "Source" Shock Levels



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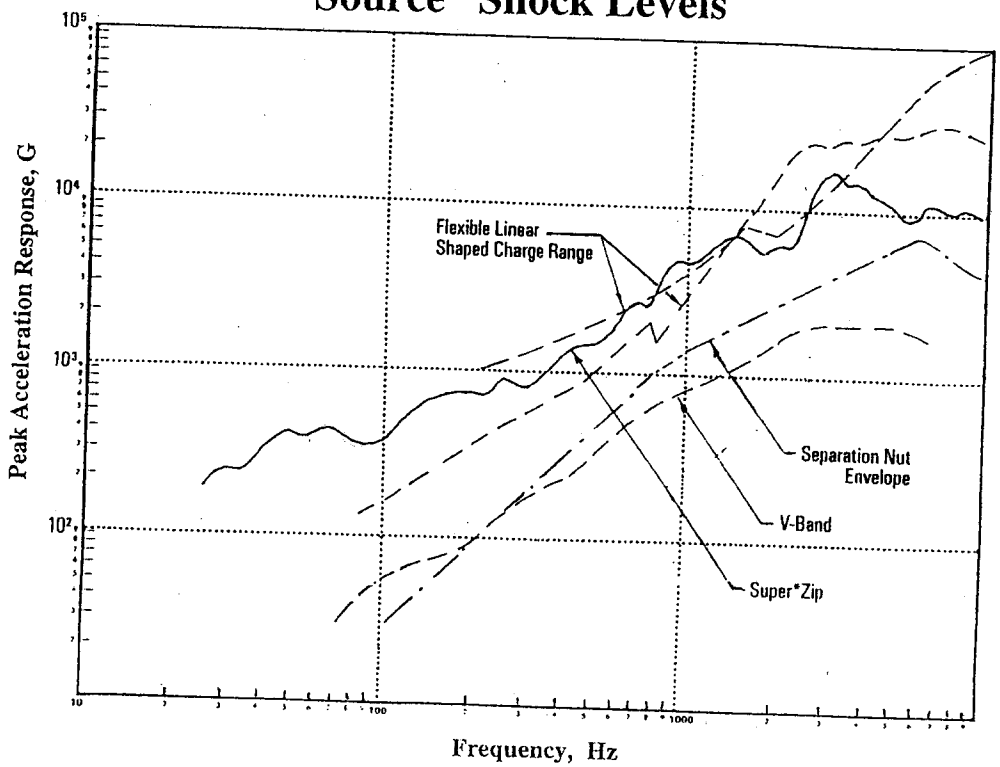

Summary Remarks

- FLSC has the highest shock generation potential.
- Shock intensities near pyro-devices from both low and high explosive actuation are the same order of magnitude.
- "Source" shocks are measures of structural response close to a device, not a measure of the shock input to the structure.
- Local structure properties (material, stiffness, joint) have a large influence on shock response measurements.
- Shock levels should be measured from flight-like or close representation of the flight device and flight structure system. For dissimilar test configuration, the uncertainty in shock measurements can approach an order of magnitude.
- Firing-to-firing variations of shock response levels can be as high as 6 dB.

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